20020503 075

Mobility Issues for LVSR

Randy Jones (601) 634-4145

Greg Green (601) 634-2871

DEDOOT DO		Form Approved
REPORT DO	CUMENTATION PAGE	OMB No. 0704-0188
data needed, and completing and reviewing this collection this burden to Department of Defense, Washington Headqu	estimated to average 1 hour per response, including the time for reviewing instruction of information. Send comments regarding this burden estimate or any other aspect parters Services, Directorate for Information Operations and Reports (0704-0188), 1 any other provision of law, no person shall be subject to any penalty for failing to cool of the ABOVE ADDRESS.	of this collection of information, including suggestions for reducing 215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-
1. REPORT DATE (DD-MM-YYYY)	2. REPORT TYPE	3. DATES COVERED (From - To)
17-12-1999	Mobility Issues Analysis	. ,
4.Title AND SUBTITLE	And the second s	5a. CONTRACT NUMBER
NRMMII Stochastic Mobility	Issues For Logistic Vehicle System	
1	3	5b. GRANT NUMBER
Replacement (LVSR)		
(2.51.)		5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)		5d. PROJECT NUMBER
Greg Green, Randy Jones		
		5e. TASK NUMBER
		Se. TASK NOWIDEK
		5f. WORK UNIT NUMBER
		SI. WORK UNIT NUMBER
7 DEDECRIMING ORGANIZATION MAME	C) AND ADDRESS/FS)	8. PERFORMING ORGANIZATION REPORT
7. PERFORMING ORGANIZATION NAME(3) AND ADDRESS(ES)	NUMBER
Jacobs Sverdrup Technology		TOMBER .
Inc.		
25 Clement Drive, Suite 10	1	
,	1	
Quantico, Virginia 22554		
9. SPONSORING / MONITORING AGENCY		10. SPONSOR/MONITOR'S ACRONYM(S)
Marine Corps Systems Comma	nd	MARCORSYSCOM
2033 Barnett Ave Suite 315		
Quantico, Virginia 22134-5	010	11. SPONSOR/MONITOR'S REPORT
		NUMBER(S)
12. DISTRIBUTION / AVAILABILITY STAT	EMENT	
Distribution Statement A		
13. SUPPLEMENTARY NOTES		
None		
None		
14. ABSTRACT	to an har taraktera (1973) a comp	and hamila factoria that
	is was to identify vehicle parameters	
	st mobility over different mission ar	
identify vehicle parameter	modifications that will improve LVSR	mobility performance.

15. SUBJECT TERMS

NRMMII, HMMWV, LVS, AAAV, M1A1, M1A2, PLS, and MTVR.

16. SECURITY CLASS Unclassified			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON Timothy L. McMahand
a. REPORT	b. ABSTRACT Unclassified	c. THIS PAGE	SAR	53	19b. TELEPHONE NUMBER (include area code) (540) 657-8000 ext#113

Standard Form 298 (Rev. 8-98) Prescribed by ANSI Std. Z39.18

AQM02-08-1416

Purpose

 Implement Stochastic Mobility Modeling methodologies that assist in assessing/developing LVSR.

Scope

- parameters and terrain features that impede mobility. . Use Stochastic Mobility Modeling to identify vehicle
 - Forecast mobility over different mission areas of / interest.
 - Identify vehicle parameter modifications which will improve LVSR mobility performance.

NRMMII Summary

NRMMII - A computer-based collection of equations and algorithms designed to predict the steady-state operating capability of a given vehicle in a prescribed terrain.

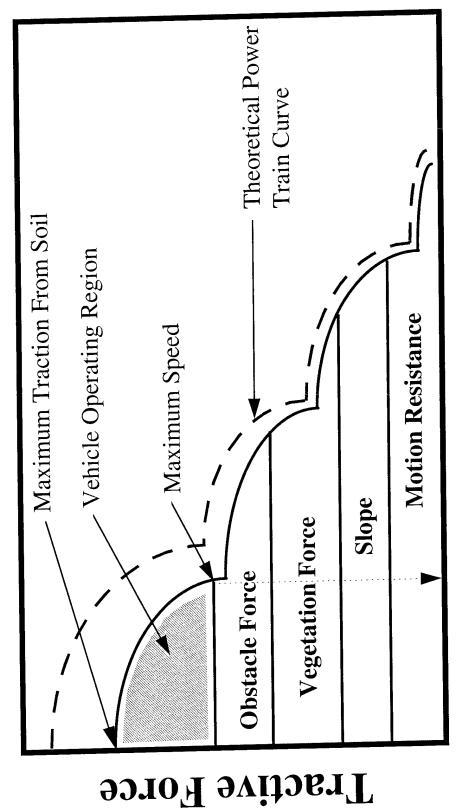
Areas

- Philippines (Mindanao Island)
- South Korea (Eastern Coast)
- Saudi Arabia/Kuwait (Eastern Coast)

Scenarios

- Dry Normal
- Average soil strength and moisture for the 30 driest days in an average raintall year
- Wet Slippery
- Average soil strength and moisture for the 30 wettest days in an average rainfall year

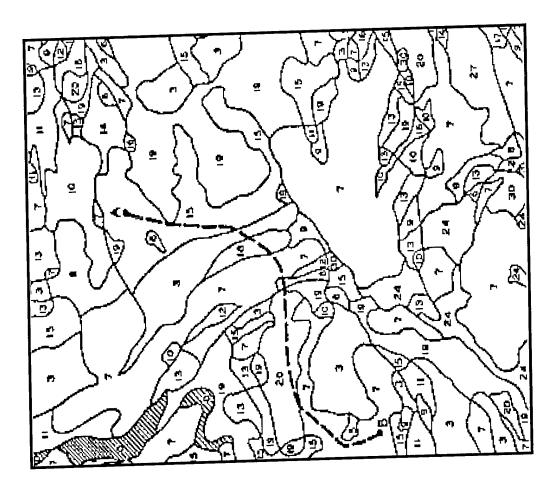
Tractive Force Speed Curve



SPEED

JUL28.PRI

Terrain Unit Mapping



Terrain Parameters

- Surface Roughness
- Soil Depth to Bedrock
- Road Super-elevation Angle
- Slope Percent
- Obstalce Approach Angle
- Obstacle Height
- Obstacle Length
- Obstacle Spacing
- Obstacle Width

- Soil Strength
- Recognition Distance
- Road Radius of Curvature
- Stem Spacing Stem Diameter
- Standing Water Depth

Significant Vehicle Parameters

Vehicle Geometry

PBF Maximum pushbar force vehicle can withstand Driver's eye-height above ground. Aerodynamic drag coefficient. EYEHGT

overriding vegetation.

Height of pushbar above ground. Vehicle projected frontal area.

Vehicle length from 1st wheel to last wheel. Length of each vehicle unit. Waterways Experiment Station
TRANS TO STATE TO S

Maximum combination vehicle width.

Traction Components

Tire Deflection for each assembly an deflection case. DFLCT

Undeflected tire diameter for each assembly. Tire nominal section width. SECTW DIAW

Maximum tire speed limit for each deflection scenario. VTIRMX

Suspension

Limited speeds for RMS roughness versus limited speed data. VRIDE

Limiting speeds for obstacle height versus 2.5 G limited speed data.

VOOB

Weight

Weight beneath each vehicle assembly.

WGHT

Transmission gear ratios and efficiencies. Combination vehicle braking coefficient. XBRCOF

Tire revolutions per mile for each assembly.

Maximum net torque from each engine.

Final drive gear ratio and efficiency.

Engine displacement.

Power Train

Engine to torque-converter gear ratio and

efficiency.

NRMMII "NOGO" Reason Codes

Visibility

Soil and Slope Resistance

Obstacle Clearance Interference

Obstacle Belly Interference

Vegetation OverrideObstacle Override

Soil NO-GO

Sliding

Tipping .

NRMMII "GO" Reason Codes

, Ride Dynamics Limit

Tire Speed Limit

Soil, Slope, & Veg Resistance

Visibility

Maneuver Around Obst and Veg

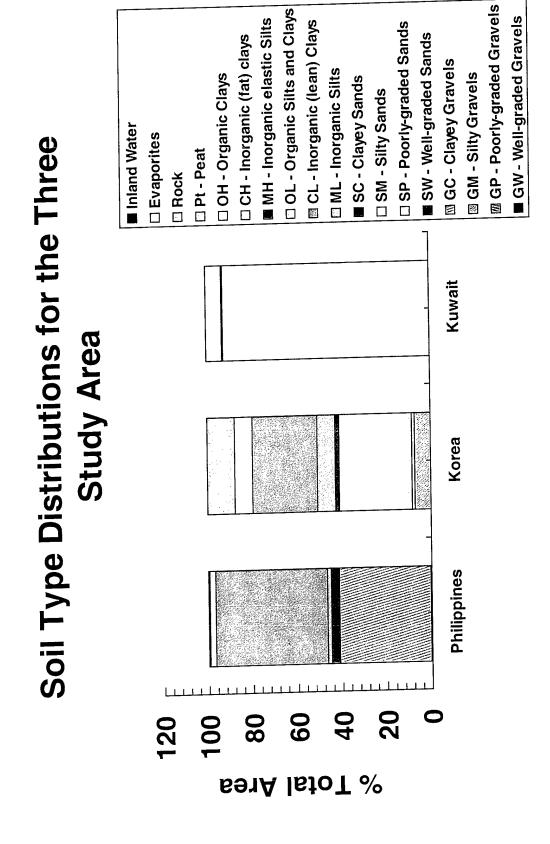
Maneuver Around Veg

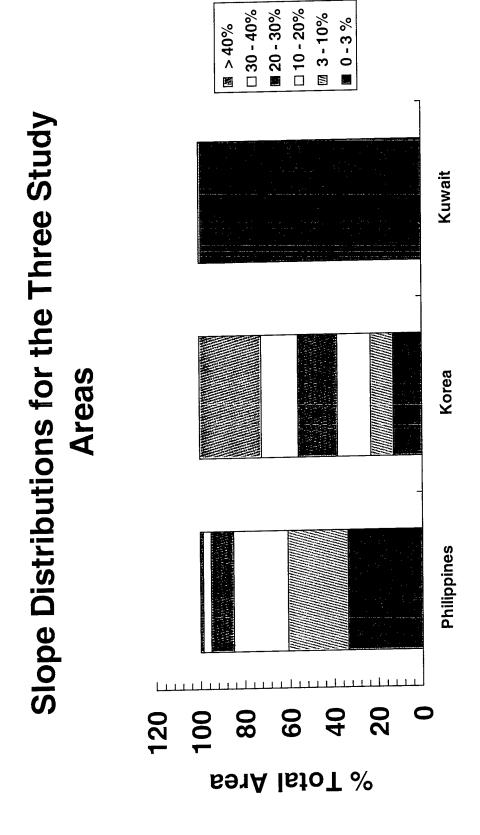
Obstacle Impact Speed

Obstacle Override Force
 Driver Prudence Over Veg

Sliding on Curves

Tipping on Curves

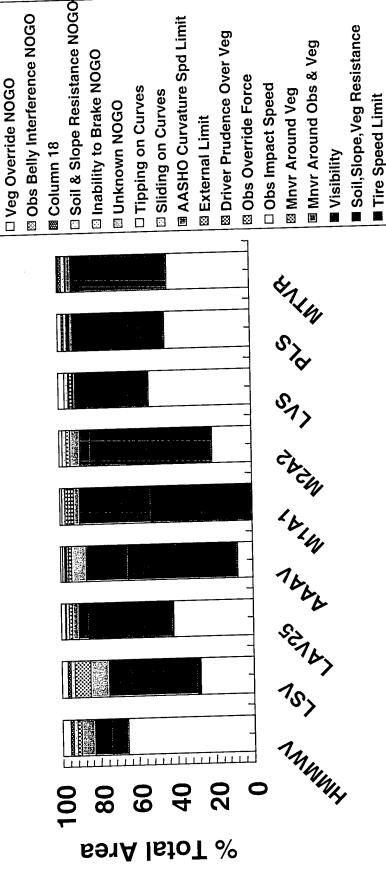




Philippines for Off-Road and Dry-Normal Season ■ Tipping NOGO (Uniform ±25% Variance)

Sliding NOGO

Soil NOGO



□ Ride Dynamics Limit

■ No Prediction

Philippines for Off-Road and Wet-Slippery Season

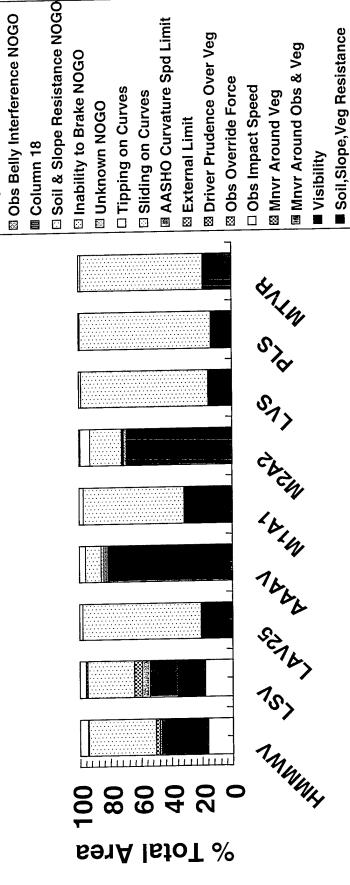
(Uniform ±25% Variance)

■ Tipping NOGO
■ Sliding NOGO

■ Obs Override NOGO

Soil NOGO

☐ Veg Override NOGO



JUL28.PRE

Bide Dynamics Limit

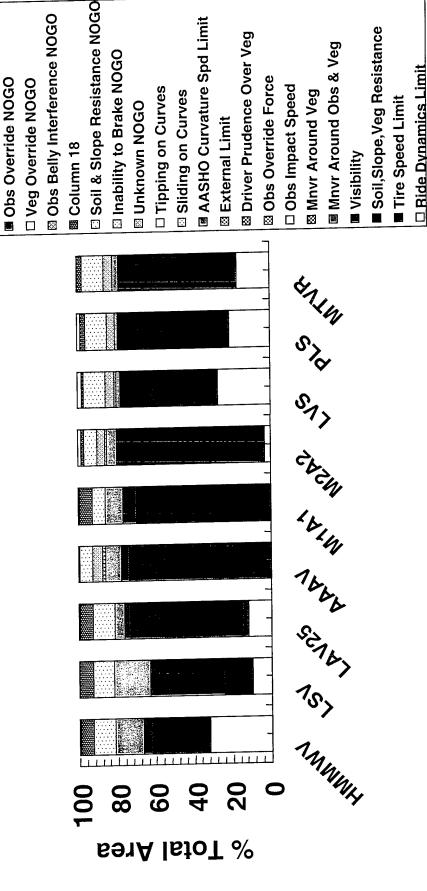
■ No Prediction

Tire Speed Limit

Tipping NOGO Korea for Off-Road and Dry-Normal Season (Uniform ±25% Variance)

Sliding NOGO

Soil NOGO



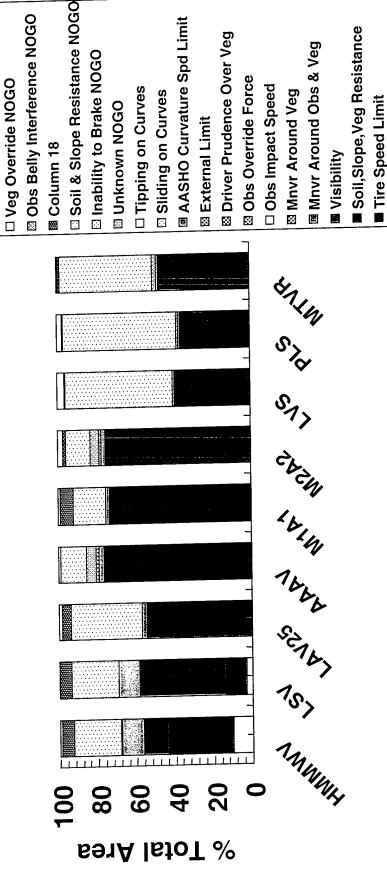
■ No Prediction

□ Tipping NOGO Korea for Off-Road and Wet-Slippery Season (Uniform ±25% Variance)

■ Obs Override NOGO

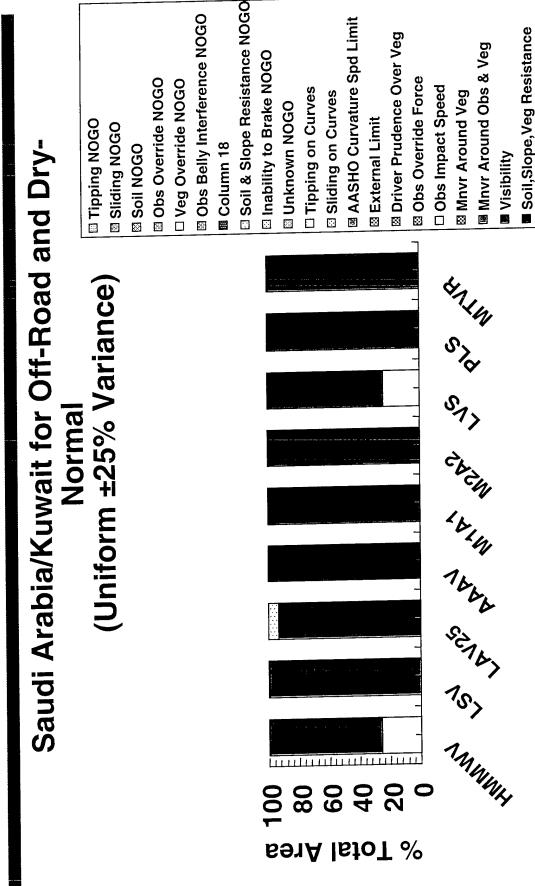
Sliding NOGO

Soil NOGO



□ Ride Dynamics Limit

■ No Prediction



□ Ride Dynamics Limit

■ No Prediction

Tire Speed Limit

% Total Area

🗆 Soil & Slope Resistance NOGO Obs Belly Interference NOGO ■ AASHO Curvature Spd Limit □ Driver Prudence Over Veg ■ Mnvr Around Obs & Veg Inability to Brake NOGO ■ Obs Override NOGO ☐ Veg Override NOGO ☐ Tipping on Curves □ Obs Impact Speed Sliding on Curves ■ Minvr Around Veg Unknown NOGO □ Tipping NOGO Sliding NOGO Saudi Arabia/Kuwait for Off-Road and Wet-**■ Column 18** Soil NOGO (Uniform ±25% Variance) ATHIS OF ST CHEN WIN MAN SON TO Slipper 80 60 40

■ Soil, Slope, Veg Resistance

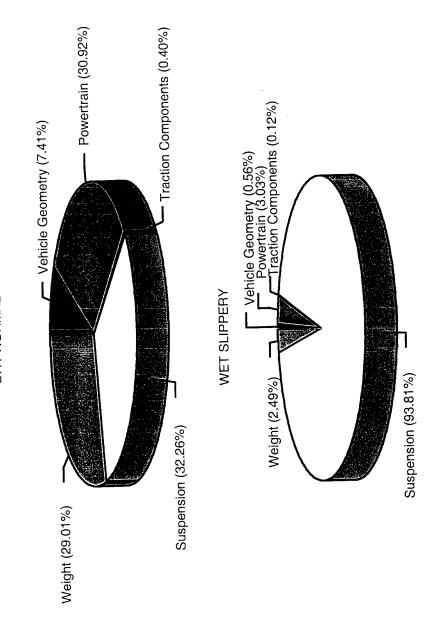
Visibility

□ Ride Dynamics Limit

■ No Prediction

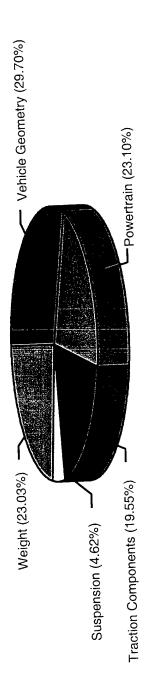
■ Tire Speed Limit

DRY NORMAL

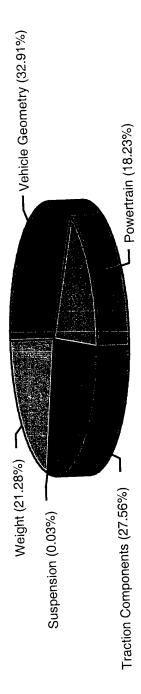


Significant LVS Vehicle Parameters South Korea, Off-Road, 20% Variance

DRY NORMAL

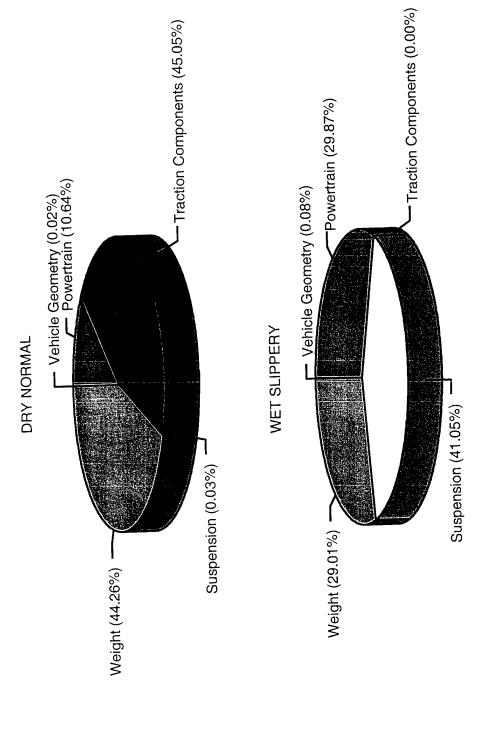


WET SLIPPERY



Significant LVS Vehicle Parameters





■ POWERY ■ SECTW □ VULEN **NAIDE ■ WDTH** □ DIAW □ WGHT ■ ACD ■ PFA Mindanao, Philippines, Off-Significant LVS Vehicle **WET SLIPPERY** Road, 20% Variance **Parameters** DRY NORMAL 100 150 Area % Total

■ ACD

3421i, South Korea, Off-Significant LVS Vehicle Road, 20% Variance **Parameters**

■ VULEN

□ WDTH

WGHT

VRIDE

■ VOOB

■ POWERY □ SECTW **M** QMAX ■ PFA ■ DIAW ☐ REVM **WET SLIPPERY** DRY NORMAL 100 150 Area % Total

Significant LVS Vehicle

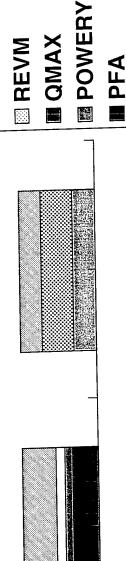
5546i, Saudi Arabia/Kuwait, Off-Road, 20% Variance **Parameters**

■ XBRCOF

■ VRIDE

■ VOOB

™ WGHT



REVM

DRY NORMAL

WET SLIPPERY

■ DIAW

I PFA

■ ACD

JUL28.PRE

100

Area

% Total

Dry Normal 50th Percentile Speed (±25%) Tire Speed Limit Mindanao, Philippines, Off-Road, 100 LVS Speed/Reason Profile **Iterations**

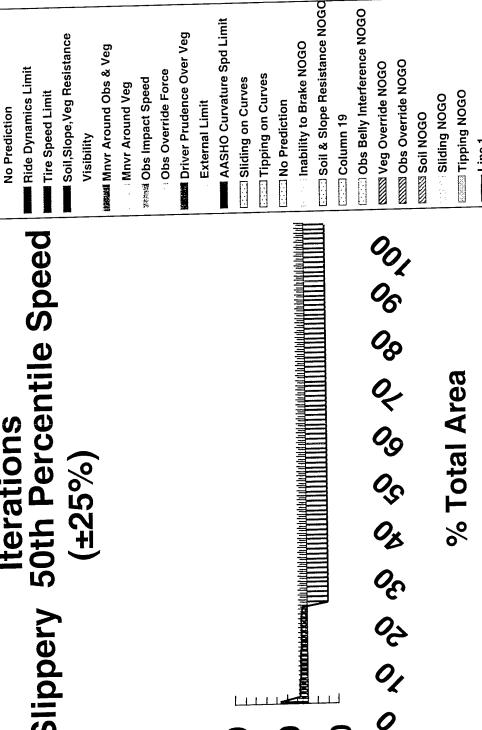
Soil & Slope Resistance NOGO Obs Belly Interference NOGO **AASHO Curvature Spd Limit Makes** Driver Prudence Over Veg Inability to Brake NOGO 臨時間 Mnvr Around Obs & Veg mm Obs Override NOGO MINITY Veg Override NOGO Ride Dynamics Limit Obs Override Force Tipping on Curves Mayord Obs Impact Speed Sliding on Curves Mnvr Around Veg Tipping NOGO Sliding NOGO No Prediction **External Limit** No Prediction Column 19 Soil NOGO Visibility THE THE THE PERSON OF THE PERS

> 70 50 30 10 -10 MPH Average Speed,

Materways Experiment Station

% Total Area

LVS Speed/Reason Profile Mindanao, Philippines, Off-Road, 100 Wet Slippery 50th Percentile Speed Iterations $(\pm 25\%)$



JUL28.PRE

% Total Area

Average

20

MPH

'pəədS

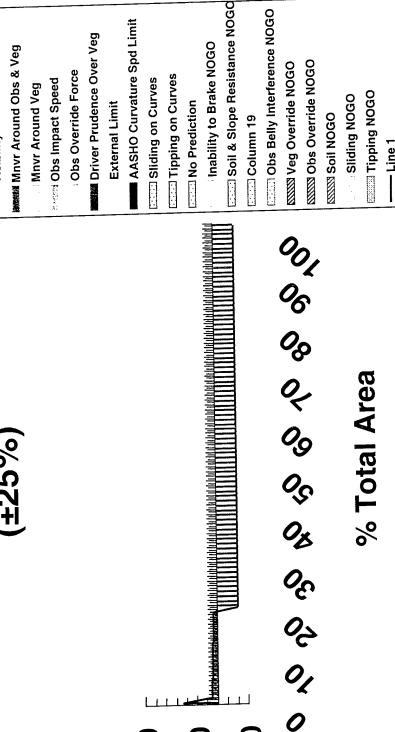
Mindanao, Philippines, Off-Road, 100 PLS Speed/Reason Profile **Iterations**

Dry Normal 50th Percentile Speed (±25%)

Soil & Slope Resistance NOGO Obs Belly Interference NOGO I AASHO Curvature Spd Limit **歐鄰國** Driver Prudence Over Veg Soil, Slope, Veg Resistance Inability to Brake NOGO **翻版 Mnvr Around Obs & Veg MINIO Obs Override NOGO** MININ Veg Override NOGO Ride Dynamics Limit Obs Override Force Tipping on Curves See 3 Obs Impact Speed Sliding on Curves Mnvr Around Veg Tipping NOGO Sliding NOGO Tire Speed Limit No Prediction External Limit No Prediction Soil NOGO Column 19 Visibility

Waterways Experiment Station

% Total Area



JUL28.PRE

% Total Area

20

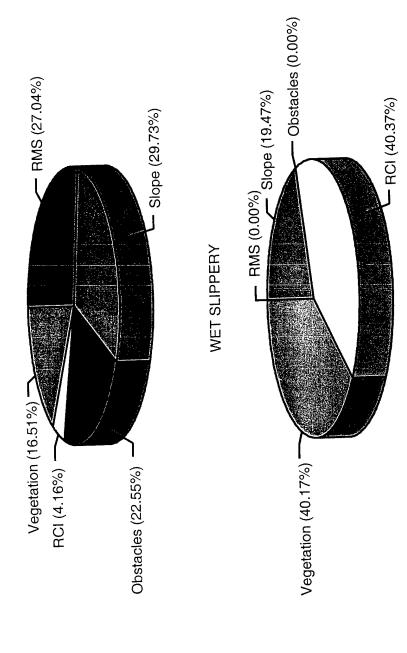
Average

MPH

'pəədS

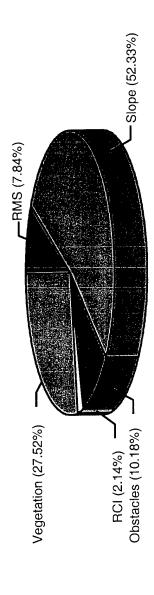
Significant Terrain Parameters for LVS Philippines, Off-Road, 25% Variance

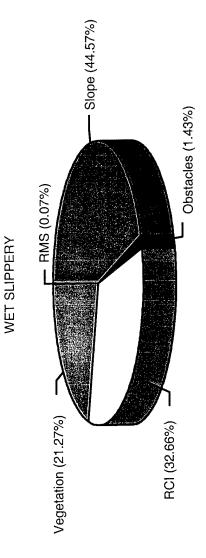
DRY NORMAL



Significant Terrain Parameters for LVS Korea, Off-Road, 25% Variance

DRY NORMAL

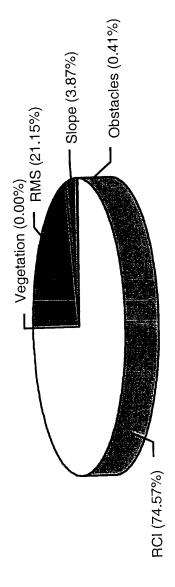


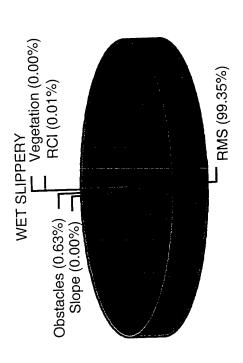


Significant Terrain Parameters for LVS

Kuwait, Off-Road, 25% Variance

DRY NORMAL





XBRCOF

5546i, Saudi Arabia/Kuwait,

Parameters

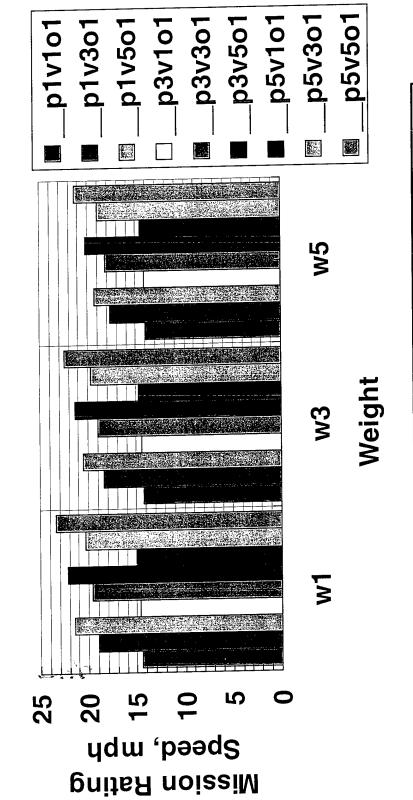
Significant LVS Vehicle

Off-Road, 20% Variance

Waterways Experiment Station

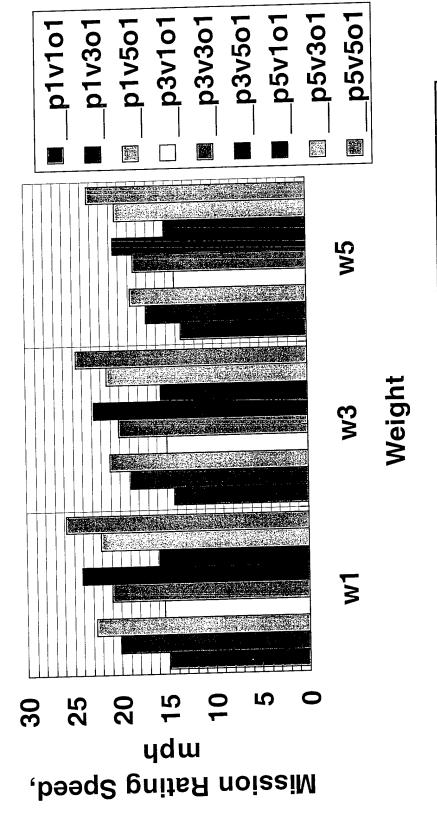
LVSR Mission Percentages

Percent of "Best" Terrain/Road Units On Operating Distance on	condary Off- Primary Secondary Off- Aoads Trails Road	Philippines	20 30 40 100 100 90 80	Korea	20 30 40 100 100 90 76	Kuwait	20 30 40 100 100 80
Percent of "Best" Terrain/Road Uni	Secondary Roads Trails		20 30		20 30		20 30
	Primary Roads		10		10		10



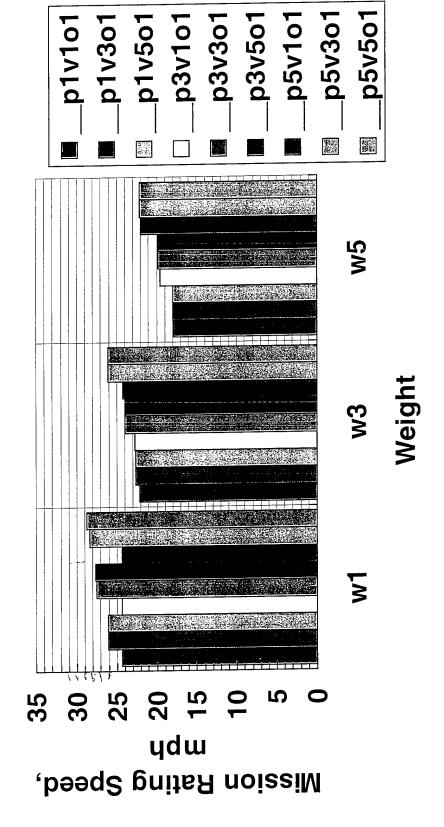
				-
w1 = 12.5 ton	p1 = 445 hp	v1 = standard	o1 = standard	
w3 = 16.5 ton	p3 = 500 hp	v3 = improved standard		
w5 = 22.5 ton	p5 = 600 hp	v5 = independent		
				7

LVSR MSR Performance in Korea



Suspension (Shock) o1 = standard v3 = improved standard v5 = independent Suspension (Ride) v1 = standard **Engine Power** p1 = 445 hp p3 = 500 hp p5 = 600 hpPayload Weight w1 = 12.5 ton w3 = 16.5 ton w5 = 22.5 ton

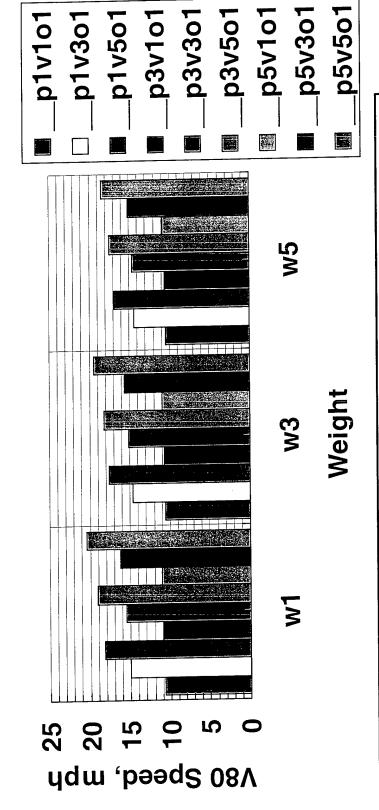
LVSR MSR Performance in Kuwait



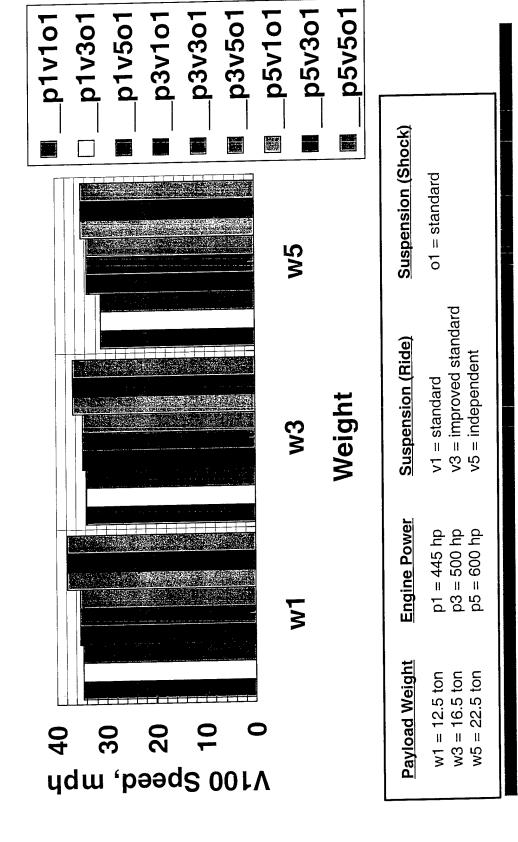
Payload Weight	Engine Power	Suspension (Ride)	Suspension (Shock)
w1 = 12.5 ton w3 = 16.5 ton w5 = 22.5 ton	p1 = 445 hp p3 = 500 hp p5 = 600 hp	v1 = standardv3 = improved standardv5 = independent	o1 = standard

Waterways Experiment Station

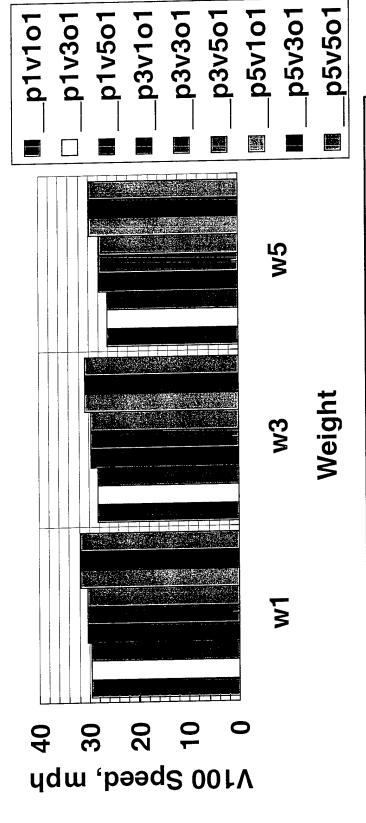
LVSR Speed Performance in the Philippines Off-Road



LVSR Speed Performance in the Philippines Primary Roads

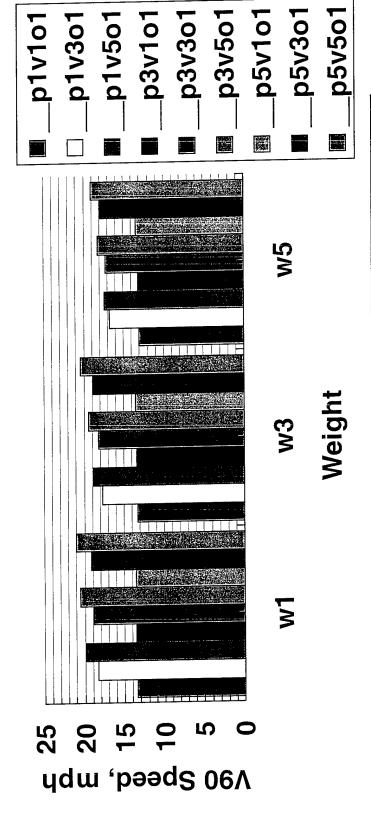


LVSR Speed Performance in the Philippines Secondary Roads

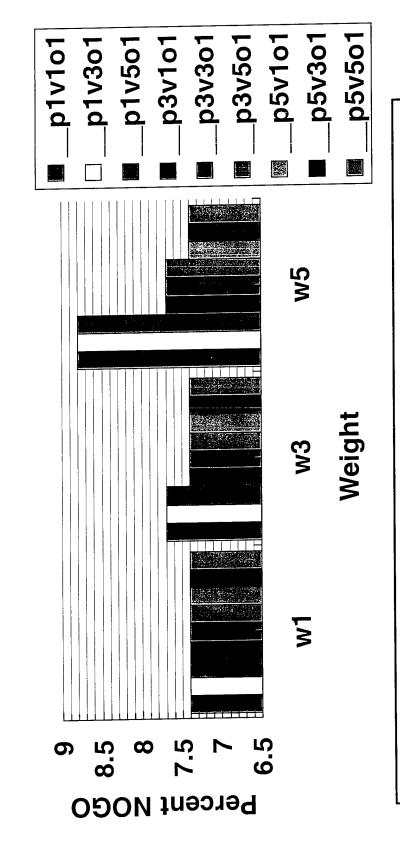


Suspension (Shock)	o1 = standard
Suspension (Ride)	v1 = standard v3 = improved standard v5 = independent
Engine Power	p1 = 445 hp p3 = 500 hp p5 = 600 hp
Payload Weight	w1 = 12.5 ton w3 = 16.5 ton w5 = 22.5 ton

LVSR Speed Performance in the Philippines Trails



Payload Weight	Engine Power	Suspension (Ride)	Suspension (Shock)
w1 = 12.5 ton w3 = 16.5 ton w5 = 22.5 ton	p1 = 445 hp p3 = 500 hp p5 = 600 hp	v1 = standardv3 = improved standardv5 = independent	o1 = standard



Suspension (Shock)

Suspension (Ride)

Engine Power

Payload Weight

v1 = standard

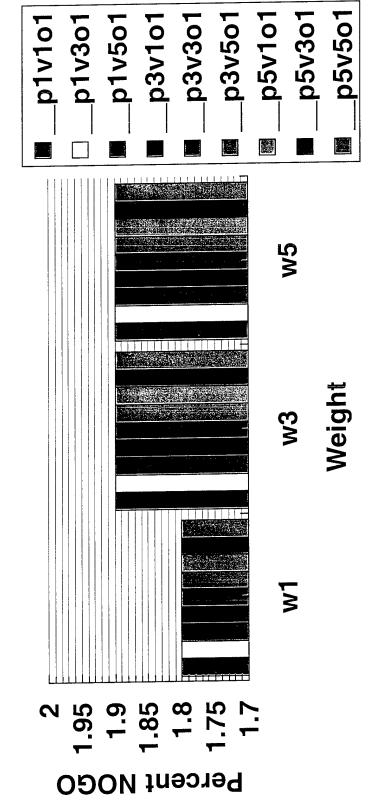
o1 = standard

v3 = improved standard v5 = independent

p1 = 445 hp p3 = 500 hpp5 = 600 hp

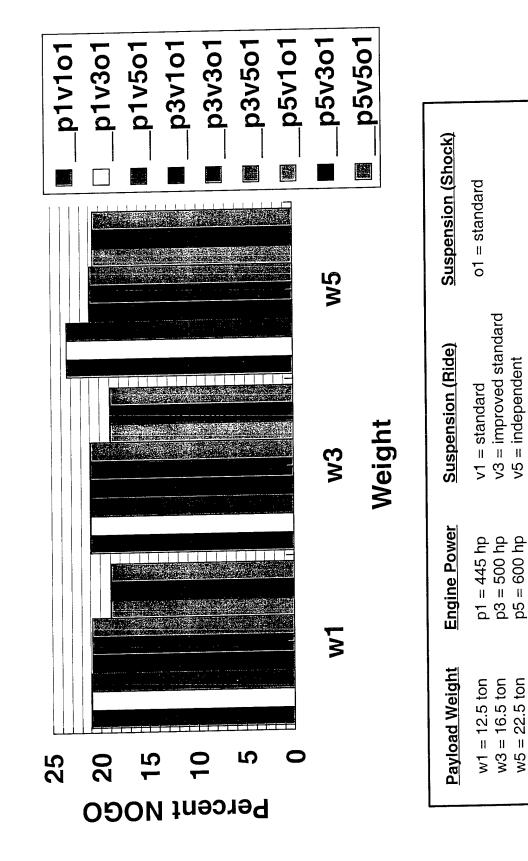
w1 = 12.5 ton w3 = 16.5 tonw5 = 22.5 ton

LVSR NOGO Performance in the Philippines On-Road

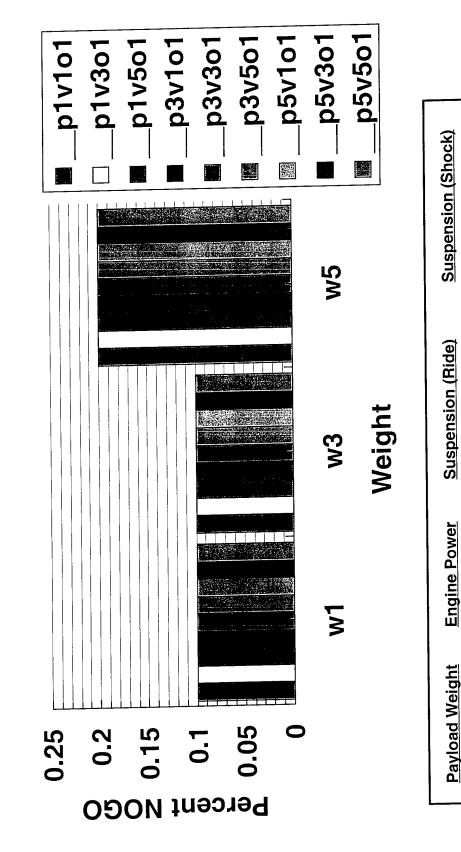


Payload Weight	Engine Power	Suspension (Ride)	Suspension (Shock)
w1 = 12.5 ton w3 = 16.5 ton w5 = 22.5 ton	p1 = 445 hp p3 = 500 hp p5 = 600 hp	v1 = standardv3 = improved standardv5 = independent	o1 = standard

LVSR NOGO Performance in Korea Off-Road



LVSR NOGO Performance in Kuwait Off-Road



o1 = standard

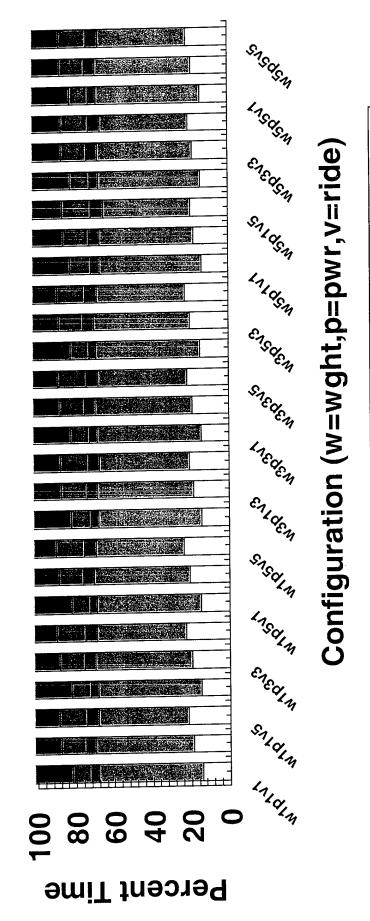
v3 = improved standard v5 = independent

p1 = 445 hp p3 = 500 hpp5 = 600 hp

w1 = 12.5 ton w3 = 16.5 tonw5 = 22.5 ton

v1 = standard

LVSR Percent Times Off-Road and On-Philippines, Mindanao Dry Normal Road



Waterways Experiment Station

□ MRS ■ Off-Road (V80) ■ Primary (V100) ■ Secondary (V100) ■ Trails (V90)

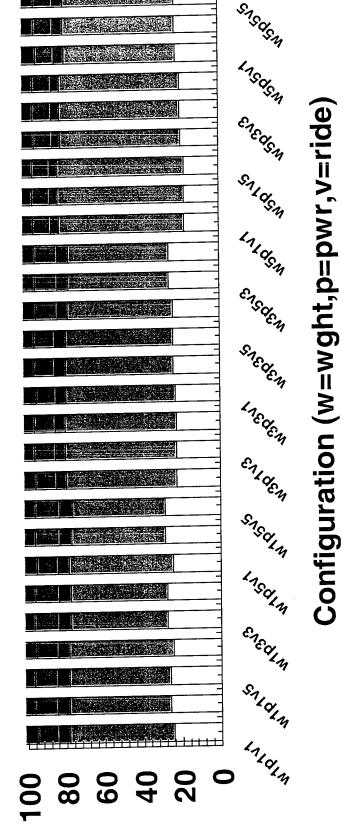
LVSR Percent Times Off-Road and On-Korea, 3421i Dry Normal Road

Configuration (w=wght,p=pwr,v=ride) LASM Engden SAEOGN In den en den SISOLIN Lasdin SALOLIN MALM 80 60 40 20 Percent Time

Waterways Experiment Station

□ MRS ■ Off-Road (V76) 圖 Primary (V100) ■ Secondary (V100) ■ Trails (V90)

LVSR Percent Times Off-Road and On-Kuwait, 5546i Dry Normal Road



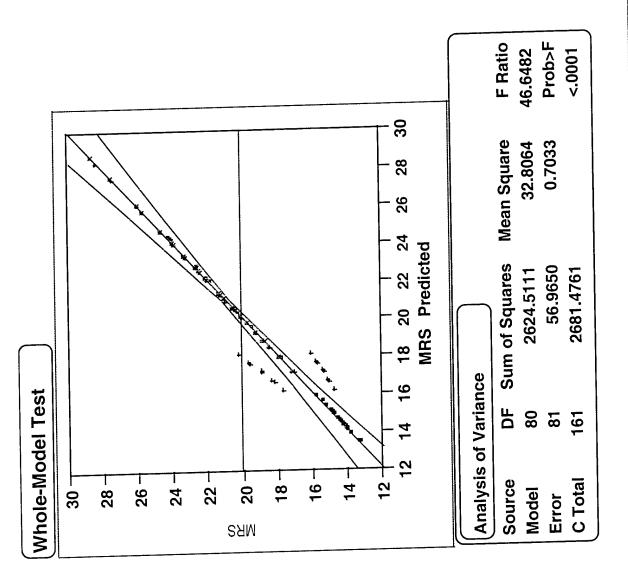
Percent Time

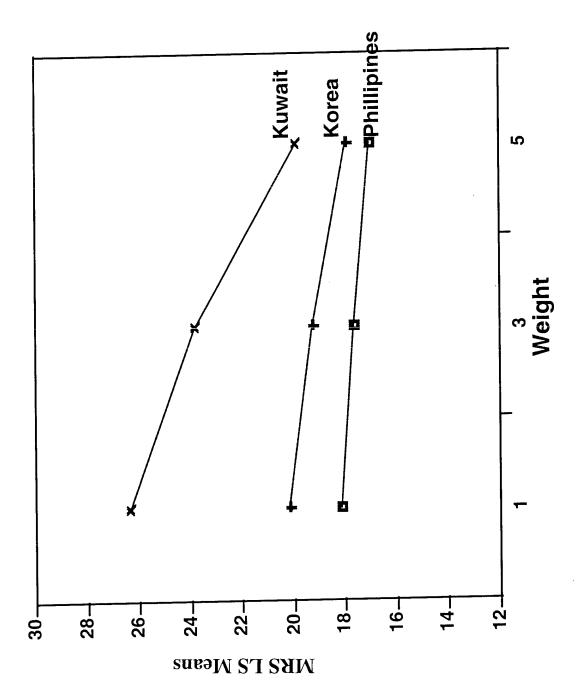
Waterways Experiment Station

□ MRS ■ Off-Road (V80) ■ Primary (V100) ■ Secondary (V100) ■ Trails (V90)

Response: MRS

RSquare 0.978756	0110			
Adj an Square Error Response tions (or Sum Wgts)10	0.978756 0.957774 0.838613 20.07593 62			
Parameter Estimates				
Effect Test				
1	NparmDF	Sum of Squares	F Ratio	Prob>F
	2	953.13000	677.6400	<.0001
Weight		296.84333	211.0446	<.0001
Country*Weight		141.73444	50.3840	<.0001
Dower		132.25593	94.0291	<.0001
Country*Power	4 4	15.49407	5.5079	9000.0
Weight*Power		6.90296	2.4539	0.0523
Country*Weight*Power		5.08037	0.9030	0.5182
Bide Bide		794.48481	564.8492	<.0001
Country*Bide	4	233.43407	82.9815	<.0001
Weight*Ride		22.88074	8.1337	<.0001
Country*Weight*Ride	8	4.69037	0.8337	0.5757
Domor*Bide		13.82370	4.9141	0.0013
Compta/*Dowor*Ride		1.84519	0.3280	0.9530
Woish**Dower*Bide	, ω ω	0.35963	0.0639	0.9998
Weight Fower*Ride Country*Weight*Power*Ride	_	1.55148	0.1379	1.0000





Waterways Experiment Station

Materways Experiment Station

